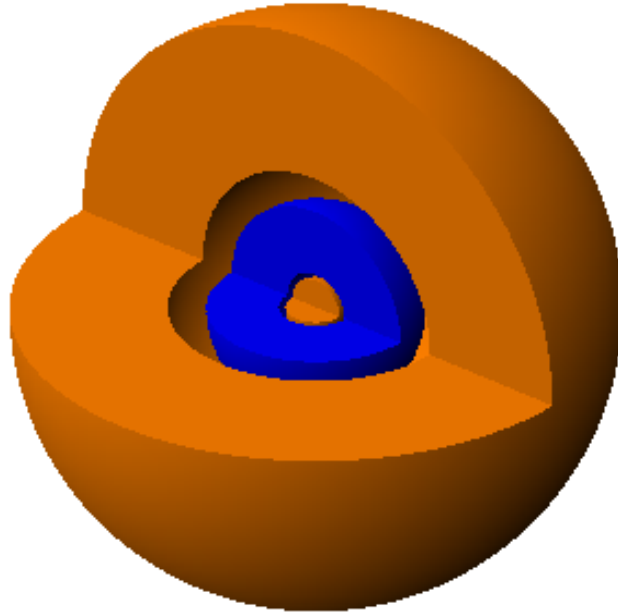


Cutaway Model of 3s Orbital

$$n = 3, l = 0, m_l = 0$$



The 3s orbital has two spherical nodes.

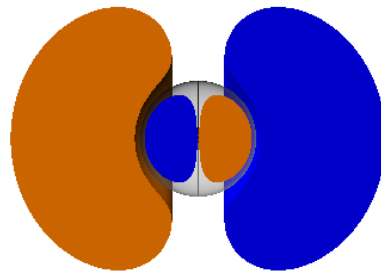
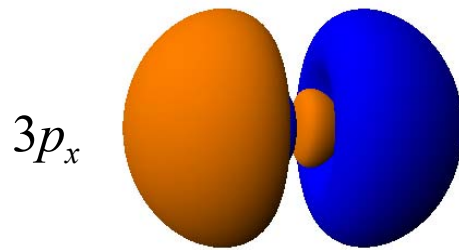
3p Orbitals

$$n = 3, l = 1, m_l = +1, 0, -1$$

Three degenerate 3p orbitals, oriented along the axes of the coordinate system ($3p_x$, $3p_y$, $3p_z$).

More extensive (bigger) than 2p with additional lobes.

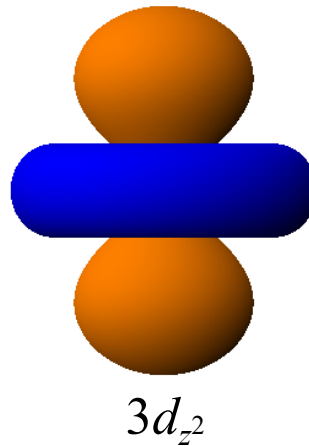
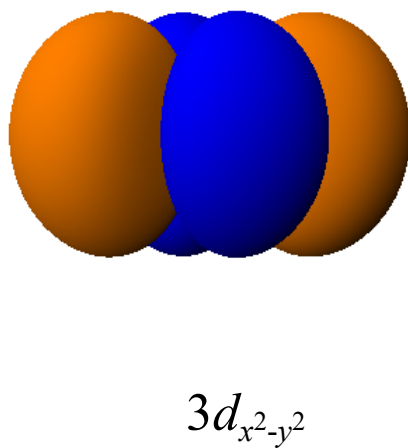
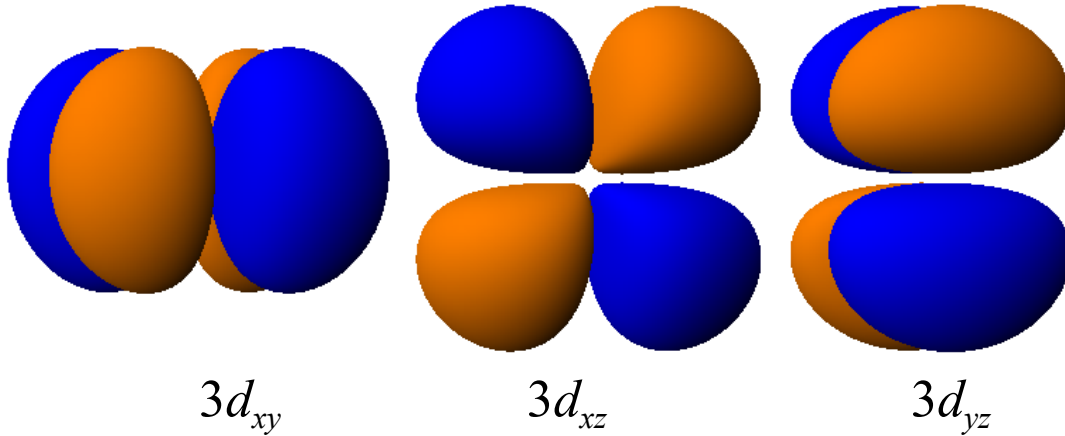
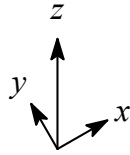
In addition to the nodal plane, inner lobes are separated from outer lobes by a spherical node.



Cutaway model showing nodes

3d Orbitals

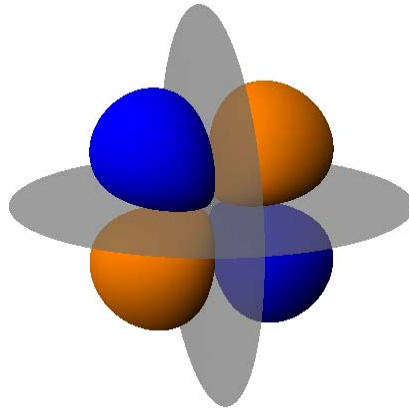
$$n = 3, l = 2, m_l = +2, +1, 0, -1, -2$$



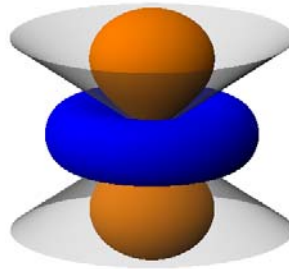
- L The $3d_{xy}$, $3d_{xz}$, and $3d_{yz}$ orbitals' lobes are *between* the axes in their names.
- L The $3d_{x^2-y^2}$ orbital's lobes are *on* the x and y axes.

Nodes of $3d$ Orbitals

- L “Cloverleaf” shaped $3d$ orbitals have two nodal planes intersecting at the nucleus, which separate the four lobes.



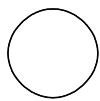
- L The $3d_{z^2}$ orbital has two nodal cones whose tips meet at the nucleus, which separate the “dumbbell” lobes from the “doughnut” ring.



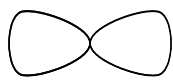
Quantum Numbers and Orbitals

n	l	m_l	Orbitals
1	0	0	$1s$
2	0	0	$2s$
2	1	-1, 0, +1	$2p_x, 2p_y, 2p_z$
3	0	0	$3s$
3	1	-1, 0, +1	$3p_x, 3p_y, 3p_z$
3	2	-2, -1, 0, +1, +2	$3d_{xz}, 3d_{yz}, 3d_{xy}, 3d_{x^2-y^2}, 3d_{z^2}$
4	0	0	$4s$
4	1	-1, 0, +1	$4p_x, 4p_y, 4p_z$
4	2	-2, -1, 0, +1, +2	$4d_{xz}, 4d_{yz}, 4d_{xy}, 4d_{x^2-y^2}, 4d_{z^2}$
4	3	-3, -2, -1, 0, +1, +2, +3	$4f$ (7 orbitals)

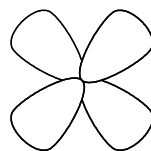
"Balloon" Models of Atomic Orbitals for Routine Sketching



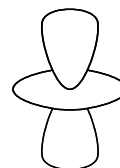
s



p



"cloverleaf" *d*



d_{z^2}

Summary

Orbitals in One-electron Atoms (H, He⁺, Li²⁺, ...)

1. All orbitals with the same value of the principal quantum number n have the same energy; e.g., $4s = 4p = 4d = 4f$. (This is *not* true for multielectron atoms.)
2. The number of equivalent (degenerate) orbitals in each subshell is equal to $2l + 1$.
3. For orbitals with the same l value, size and energy increase with n ; e.g., $1s < 2s < 3s$.
4. For orbitals of the same l value, the number of nodes increases with n .

Orbital	1s	2s	3s	4s
Nodes	0	1	2	3
Orbital		2p	3p	4p
Nodes		1	2	3